



# Transformative Power Generation



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*Technology Manager*



*November 2020*

# Coal Power Generation Challenged by Changing Power Markets

- **Current Electricity Landscape**

- Renewable energy will continue to increase in market share
- Changing market conditions require flexible power plants

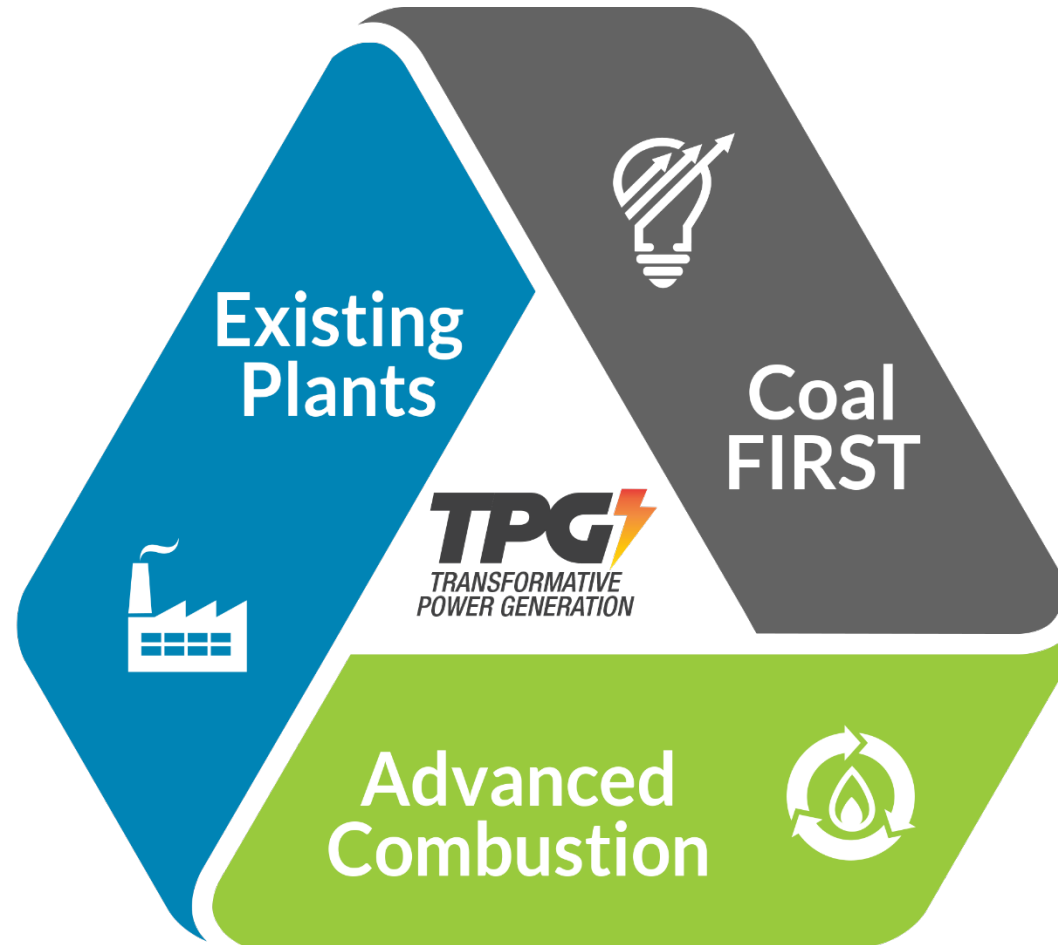
- **DOE-FE Approach**

- Ensure coal-fired generation is clean, efficient, and cost competitive
- Capitalize on the inherent stored energy and dispatchability of coal
- Develop solutions that are not one size fits all – Based on regional market needs

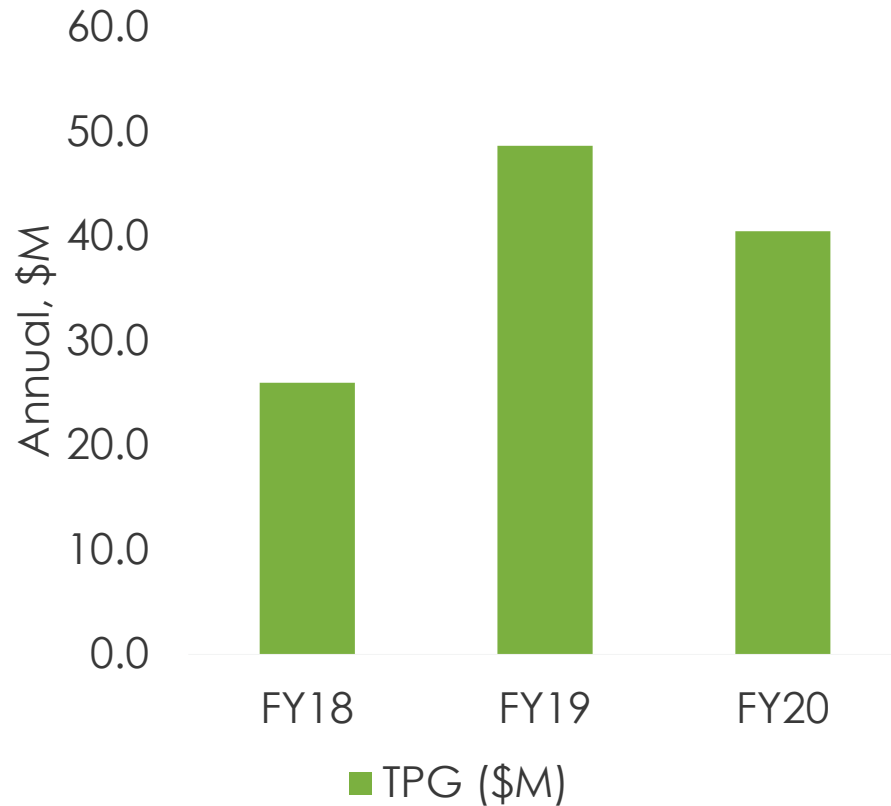


# Transformative Power Generation Program

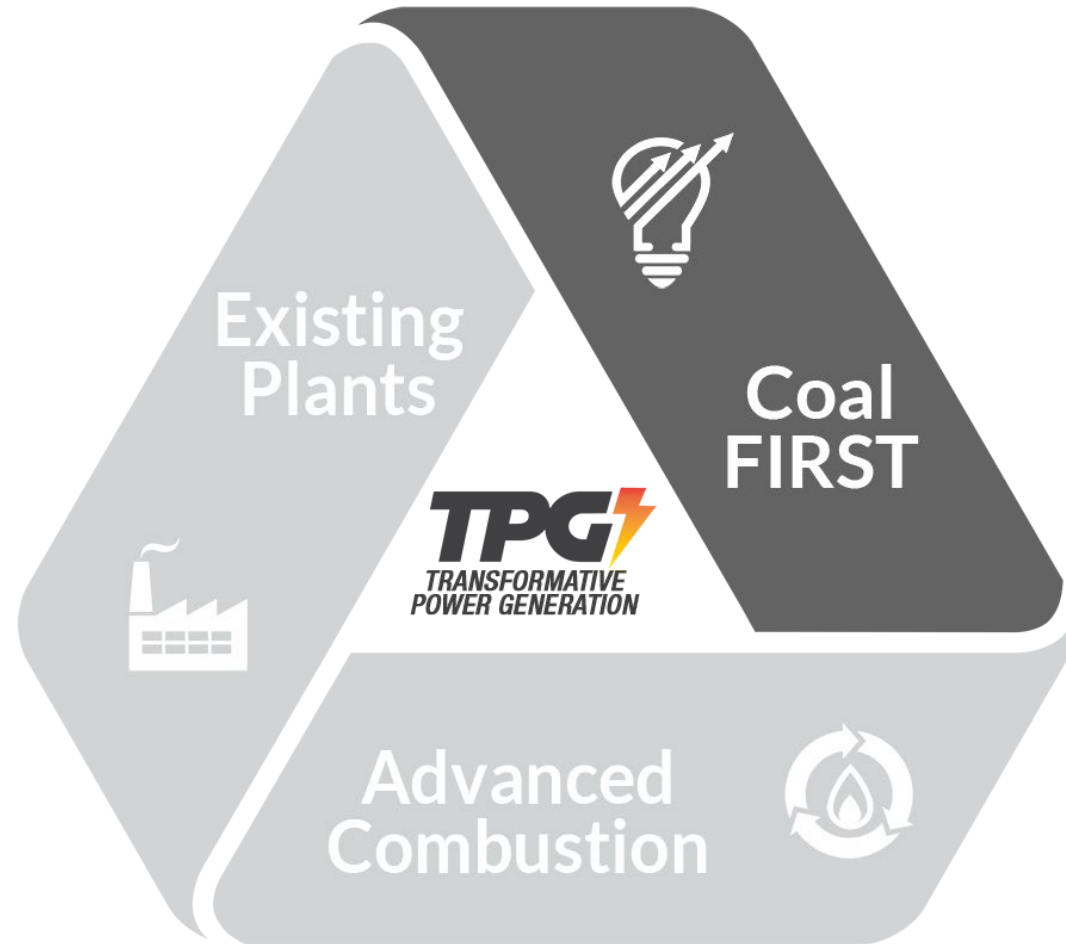
## R&D Focus Areas



# Program Budget History



Program Funding (\$M)		
FY 18 Enacted	FY 19 Enacted	FY 20 Enacted
\$26	\$48.7	\$40.5



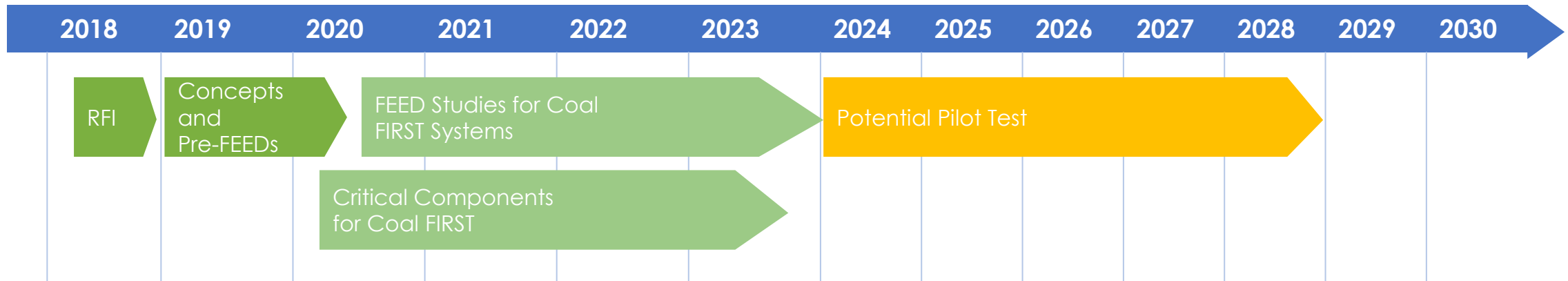
**Mid-Term**  
Implement in 4-12 years

# Coal FIRST: Mission, Need, and Goal

- Keep coal power generation in mix beyond 2050
- Capability for net negative carbon dioxide emissions is key
- Business case to enable wide-scale replication within markets



# Technology Development Schedule: Coal FIRST



## Technology Concepts and Pre-FEED Studies

- Flexible Ultra Supercritical (USC) Coal-Fired Power Plant
- Hybrid Natural Gas Turbine / USC Coal Boiler Power Plant
- Pressurized Fluidized Bed Combustor with Supercritical Steam Cycle Power Plant
- Indirect Supercritical Carbon Dioxide Power Plant System
- Direct-fired Supercritical Carbon Dioxide Power Plant System
- Gasification Based Poly-generation Power Plant System
- Coal-Fired Direct Injection Combustion Engine & Gas Turbine Compound Reheat Combined Cycle Power Plant System
- Modular Staged Pressurized Oxy-combustion Power Plant System

# Implementation Began FY19



## Coal FIRST: Coal Plant of the Future

Title	Objective	Funding (DOE/Total)	Issued	Closed
RFP No. 89243319RFE000015 <b>“Coal-Based Power Plants of the Future”</b>	Develop the program’s conceptual design with an option to conduct preliminary front-end engineering design (Pre-FEED) studies.	\$9.8M/ \$9.8M	Nov 12, 2018	Jan 25, 2019
FOA-2057 <b>“Critical Components for Coal FIRST Power Plants of the Future”</b>	Development of critical components that will support potential designs for coal-based power plants of the future.	\$37M/\$47M	Feb 7, 2020	Apr 13, 2020
FOA-0002180 <b>“Design Development and FEED Studies for Coal FIRST Systems”</b>	To make available up to ~\$81 million for cost-shared R&D projects focused on performing Front End Engineering Design (FEED) studies for the Coal FIRST plant with allowances for limited design development.	Up to \$81M/ \$101.25M	DRAFT: May 18, 2020 FINAL: July 17, 2020	Aug 26, 2020



# Coal FIRST Critical Components R&D

 Washington University in St. Louis

Development of Critical Components for the Modular Staged Pressurized Oxy-combustion Power Plant



High-Temperature Seals for Supercritical CO<sub>2</sub> Turbines

 **Media and Process Technology Inc.**

Advanced Ceramic Membranes/Modules for Ultra-Efficient H<sub>2</sub> Production/CO<sub>2</sub> Capture for Coal-Based Poly-generation Plants



Zero Emission Syngas Combustor Test



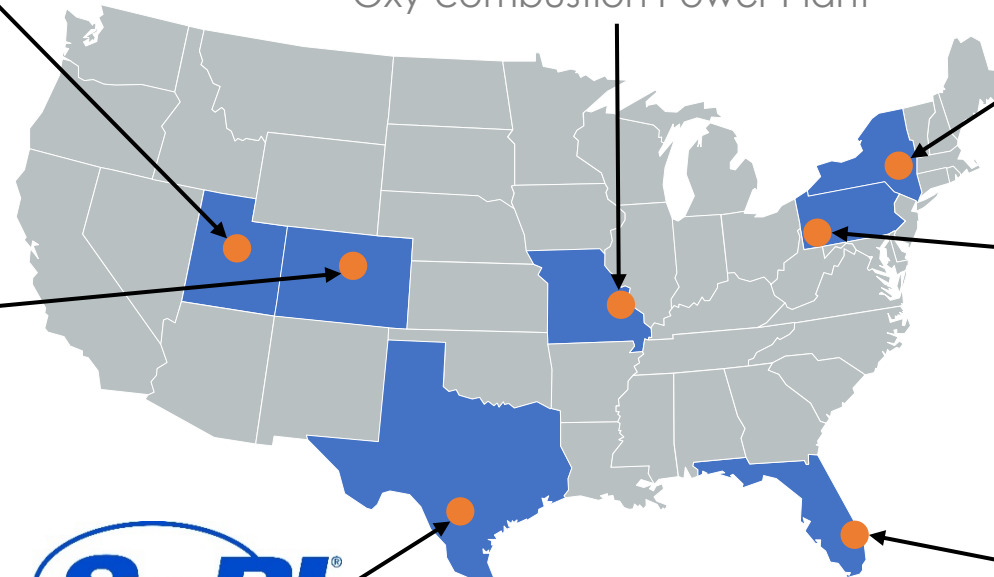
Development of Coal Syngas Oxy-Combustion Turbine for Use in Advanced sCO<sub>2</sub> Power Cycles

**BYU**

Testing and Model-Based Optimization of Coal-Fired Primary Heater Design for Indirect Supercritical CO<sub>2</sub> Power Cycles



A High-Efficiency, Modular Pre-Combustion Capture System for Coal FIRST Poly-generation Process



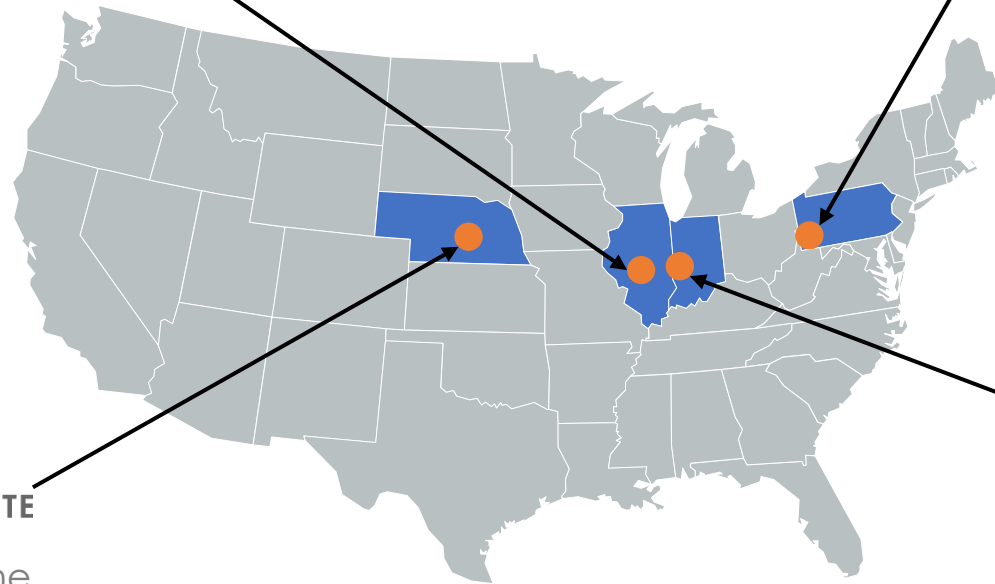
# Coal FIRST FEED FOA-2180 Selections



Front-End Engineering Design Study for Hybrid Gas Turbine and USC Coal Boiler Concept (HGCC) Plant with Post Combustion Carbon Capture and Energy Storage System at City, Water, Light and Power Plant



Design Development and System Integration Design Study for an Advanced Pressurized Fluidized Bed Combustion Power Plant with Carbon Capture



Gasification of Coal and Biomass: The Route to Net-Negative-Carbon Power and Hydrogen



Wabash Hydrogen Negative Emissions Technology Demonstration

# Accomplishments & Next Steps

## Coal FIRST: Coal Plant of the Future

### Accomplishments

- ✓ Stakeholder input (Request for Information)
- ✓ 13 Concept Studies performed
- ✓ Seven Pre-FEED Studies completed in April/May 2020

*Pre-FEED Study deliverables posted here:*

<https://netl.doe.gov/coal/tpg/coalfirst/concept-reports>

- ✓ FOA-0002057 - Selected 7 R&D projects for components of promising systems of future coal plants

*Announcement:*

<https://www.energy.gov/fe/articles/foa-2057-project-selections>

- ✓ FOA-0002180 – Selected 4 projects for Design Development and FEED Studies

*Announcement:*

<https://netl.doe.gov/node/10255>

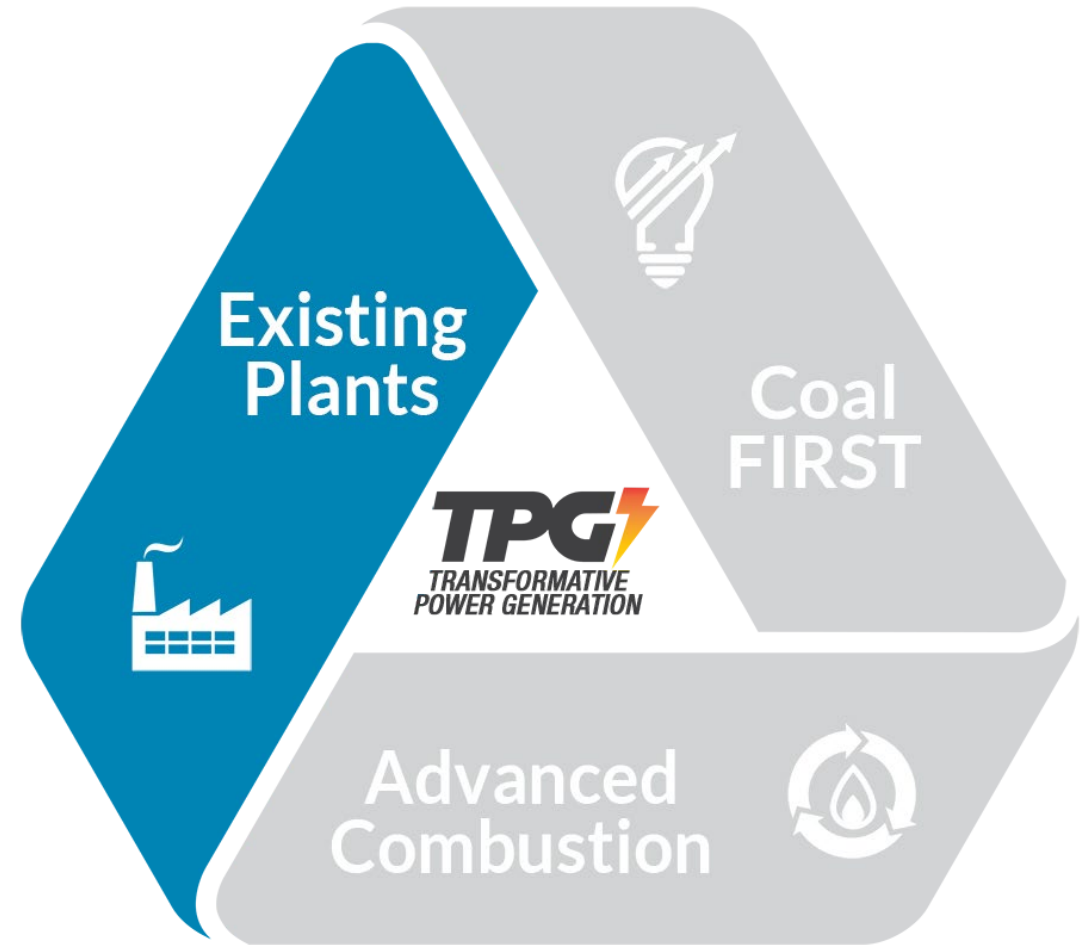
### Next Steps

- Award FEED studies  
*Fall/Winter 2020*



## Near-Term

Implement in 2-10 years



# Coal Fleet R&D – Challenges and Focus



Baseload coal plants being deployed as load-following units



Performance and equipment degradation accelerated



Assist plants with improving:

- Increased flexibility
- Improved reliability
- Optimized efficiency



# Existing Plants Projects

THE UNIVERSITY OF UTAH

MICROBEAM TECHNOLOGIES, INC.

BARR

University of Kentucky

LEHIGH UNIVERSITY



THE UNIVERSITY OF MAINE

GE Power

SIEMENS

NATIONAL ENERGY TECHNOLOGY LABORATORY

West Virginia University

RTI INTERNATIONAL

EPRI ELECTRIC POWER RESEARCH INSTITUTE

ATC Applied Thermal Coatings

CLEMSON UNIVERSITY

REACTION ENGINEERING INTERNATIONAL

EPRI ELECTRIC POWER RESEARCH INSTITUTE

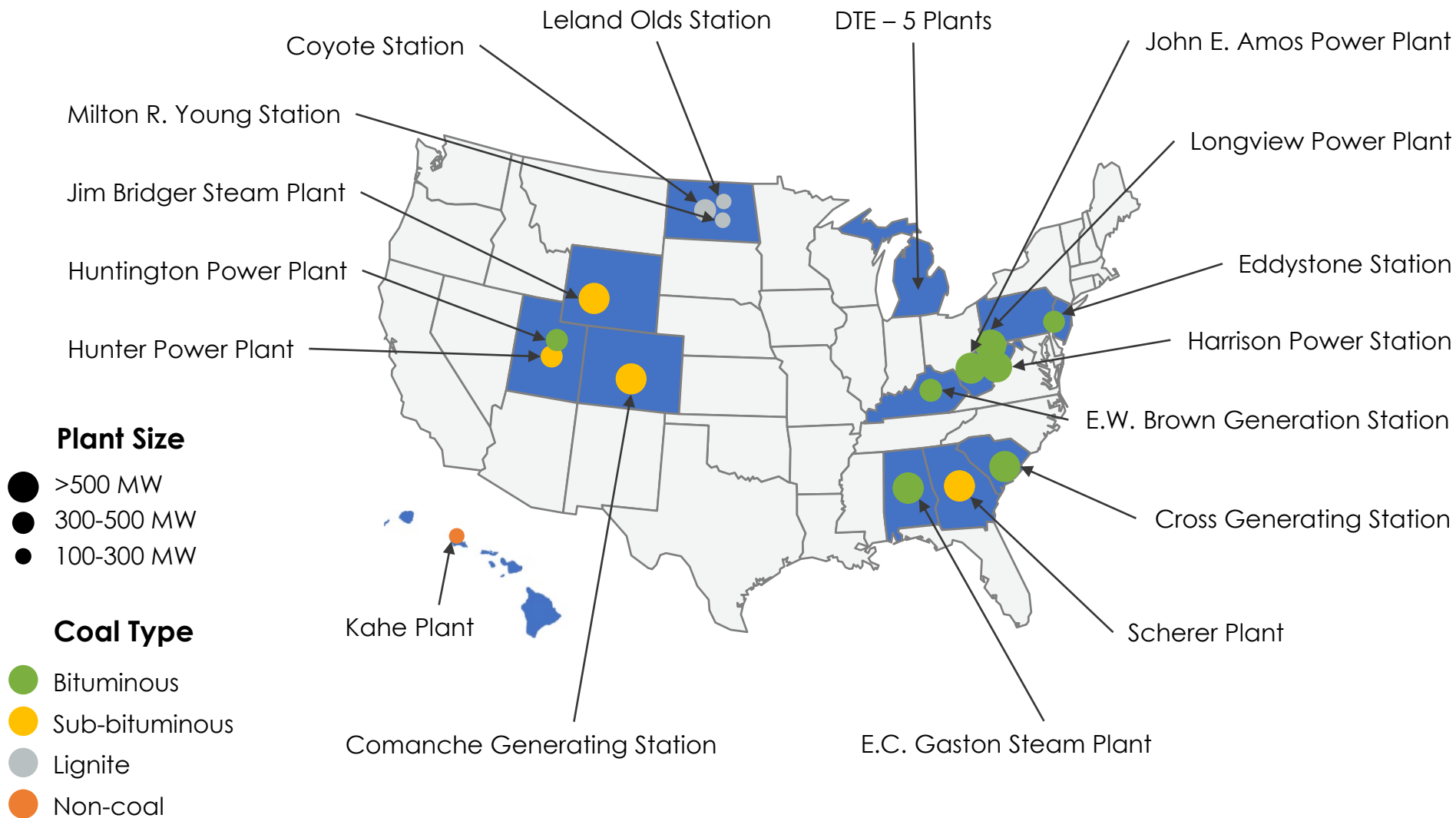
Opto Knowledge

oceanit

## ORGANIZATION TYPE (# includes partners)

- Service Provider (26)
- Equipment Manufacturer (15)
- Coal Company (1)
- Research Institute (4)
- University (18)
- National Laboratory (3)
- Utilities (24)

# Existing Plants Projects Plant Test Sites



## Technologies in Development

- Advanced Sensors (incl. temperature, corrosion, wireless, real-time, combustible gases, ash deposition)
- Reduced Low-load Technology
- Online Coal Analyzer
- Advanced Ash Management
- Dynamic Plant Control Systems for Improved Transient Operation
- Coatings for Reliability and Efficiency
- Condition-based Monitoring Systems
- Energy Storage
- Dynamic Plant Models
- Online System Identification
- Energy Systems & Market Analysis

## Improvements for Existing Plants

- ✓ Conducting field testing at over 21 power plants with 24 utilities
- ✓ Installed extended low-load boiler system
- ✓ Tested online coal tracker with combustion system performance prediction
- ✓ Tested wireless temperature and corrosion sensors
- ✓ Tested ultrasonic sensors for real-time temperature profiles
- ✓ Detected and diagnosed pre-mature equipment failure using machine learning
- ✓ Tested improved condenser coating technology



# Transformative Power Generation

Advanced Combustion R&D



## Long-Term

Implement by 2030-2035

## Washington University in St. Louis

Application: **Staged Pressurized Oxy-combustion**

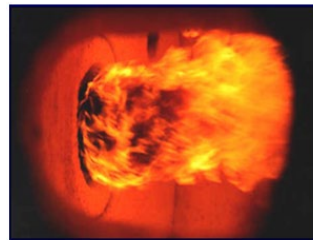


100 kW Prototype Staged Pressurized Oxy-combustor

## Southwest Research Institute

Application: **Flameless Pressurized Oxy-combustion**

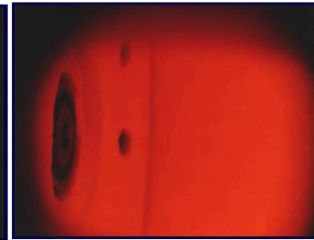
Traditional Combustion with Flame Front



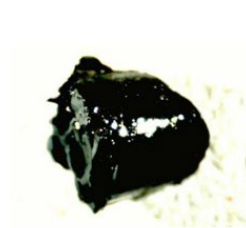
Traditional Combustor Products: Particulate



Flameless Pressurized Combustion

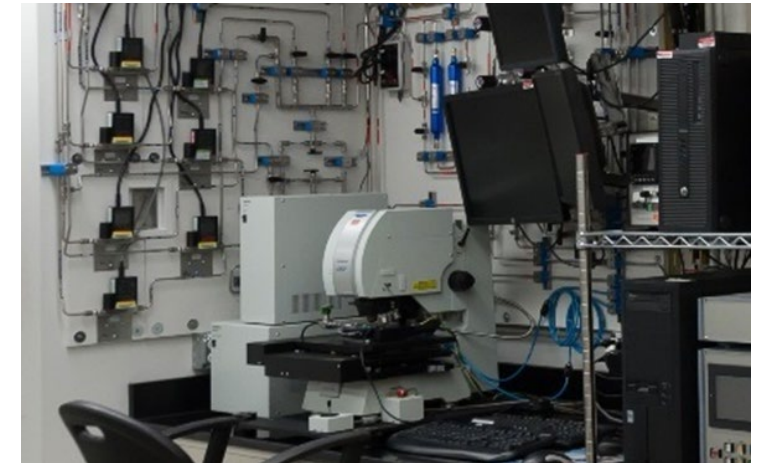


FPO Combustor Products: Near-zero carbon, neutral slag



## NETL Research and Innovation Center

Application: **Chemical Looping Combustion**



NETL's High Temperature Environmental Confocal Scanning Laser Microscope

- Coal-fired plants must be more flexible, reliable, and efficient
- Program focuses on existing and new plants
- Lab and field testing of impactful technologies underway
- All projects have industry involvement

*Stakeholder involvement essential for transition of technologies to industry*



# Questions?

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 <https://netl.doe.gov/coal/tpg>

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**TPG**  
TRANSFORMATIVE  
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